(Chron)
Rules Branch
9402126/GORE

FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

2 JUN 1994

IN REPLY REFER TO:
7310-09/1700A

Mr. William L. Schubert
Business Strategy and Planning
11154 Caminito Inocenta
San Diego, California 92126

Dear Mr. Schubert:

Thank you for your letter of April 25, 1994, to Vice President Gore, discussing the George Gilder Technology Supplement for Forbes Magazine, regarding whether the emergence of new technologies should cause the Commission to change its procedures for the planned PCS competitive bidding later this year pursuant to the 1993 Budget Reconciliation Act. I am responding on behalf of the Vice President in my capacity as Chief of the Personal Communications Services Task Force at the Federal Communications Commission.

Mr. Gilder correctly observes that less regulatory oversight is generally needed as the nation moves through the evolution to digital radio technologies incorporating extremely efficient digital signal processing, spread spectrum techniques, and the numerous other innovations that will help position our nation for international competitiveness. The Commission recognizes such developments and takes them into account. For example, it has not mandated the use of particular technologies for Air/Ground service (e.g., GTE's Airfone), for Specialized Mobile Radio systems, or indeed for broadband PCS. Similarly, it has relaxed its rules for the cellular radio service to permit the use of next-generation digital cellular processing techniques and implementation of cutting edge cellular services.

With the impending PCS auctions and in other anticipated proceedings allocating spectrum for wireless services, the Commission plans to authorize large blocks of spectrum that will be ideal proving grounds for use of techniques such as the Steinbrecher radio concept. Steinbrecher's concepts were developed in the military context for radars operating at frequencies above 30 GHz. The Commission will be interested in viewing the results of efforts to implement this technology in the commercial world, where less funds are available and lower band frequencies are employed. If such efforts meet with success, the Commission may endeavor to foster licensing techniques that would obviate the need for exclusivity in the mobile band. Nevertheless, please be aware that, because our current competitive bidding actions are in direct response to the requirements set forth in the 1993 amendments to the Communications Act, implementation of many of Mr. Gilder's suggestions would require Congress to further amend the Communications Act.

Thank you for your interest in this matter. I hope that this is responsive to your concerns.

Sincerely,

Ralph A. Haller

Ralph A. Haller
Chief, PCS Task Force

cc:
Rules Branch (Chron)
Gail Brown, PRB
LM&M Division
File Copy (Kogan)

CNTL NO: 9402126 (Gore)

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OFFICE OF THE VICE PRESIDENT

WASHINGTON

PRB
Action
2126

MAR 20 ... 1994

M E M O R A N D U M

DATE: March 31, 1994

TO: Managing Director
Federal Communications Commission
1919 M Street, N.W.
Washington, D.C. 20554

Enclosed is a letter from a constituent asking for assistance with a matter related to the Federal Communications Commission. This information was sent to the office of Vice President Gore.

On behalf of the Vice President, I am forwarding this material with the request that the issues be addressed in an appropriate and expeditious manner. An acknowledgement of receipt and a notification of this referral has been sent.

Please respond directly to the correspondent. No reply to this office is necessary.

Thank you in advance for your attention to this matter.

Sincerely,

Bill Mason

Bill Mason
Director of Correspondence
for the Vice President

BM/wem

FCC

WILLIAM L. SCHUBERT — BUSINESS STRATEGY AND PLANNING — BUSINESS CYCLE ANALYSIS AND FORECASTING

11154 CAMINITO INOCENTA, SAN DIEGO, CA 92126
619-586-1991

APR 25 1994

April 22, 1994

Mr. Albert Gore, Vice President
The White House
Washington, DC 20500

Dear Mr. Vice President:

With your expressed interest in the so called "Information Super-Highway and your avowal to prevent monopolistic control or dominance, I am writing to suggest that you look into the pending action of the Federal Communications Commission.

According to reports they are planning to auction off blocks of the electromagnetic spectrum for sole use by the successful bidders. The FCC auction, scheduled in May, will give control of 168 Megahertz of spectrum for provision of Personal Communications services based on a now obsolete technology. The situation will be as if the FCC had ruled that HDTV had to follow the ancient analog system, as the Japanese did, instead of moving to digital where we are now the leaders.

This guarantees monopolistic dominance of PCS and of even greater and indeed crucial concern, is the fact that it will put a ten year roadblock in front of the most promising new developments which will give us virtually unlimited bandwidth. Bandwith equates to communications power and if the revolutionary developments now evolving are not averted, through the air communication costs will drop by orders of magnitude. The current revolution now exploding involves the convergence of several "breakthrough" technologies, devised by Qualcomm, Donald Steinbrecher, and Douglas Shute. These developments key into the rapid acceleration of microprocessor development to over 100mghtz clock rates and from 16 to 32 and now 64 bit word processing, providing efficiency gains measured by factors of billions.

These new technologies will shift radio transmission to digital from analog. Current technologies, based on analog modulation methods, require allocation of what is perceived as a limited spectrum for exclusive use to avoid interference. The new digital technology, using a digital signal processor chip, enables many users to employ the same spectrum at frequencies all the way up light waves. Qualcomm's Code Division Multiple Access technology permits selective filtering access to the appropriate signal. Steinbrecher's technology, using digital signal processors enables the frequency tuning, modulation and demodulation, channelization and coding required to make the concept function. The technology permits instantaneous, real time, scanning of the spectrum and transmission on unused portions, routing and rerouting so as to effectively use the whole spectrum. comA

For a more detailed and thorough review of the subject I am enclosing a copy of one of George Gilder's superb articles appearing in the Forbes ASAP Technology Supplement, in case you have not seen it.

The United States is pushing the frontiers of computer and communications technologies, leaving Japan and Europe a decade or more behind. We must maintain that lead.

The FCC auction must not be allowed to happen.

Sincerely,

William Schubert

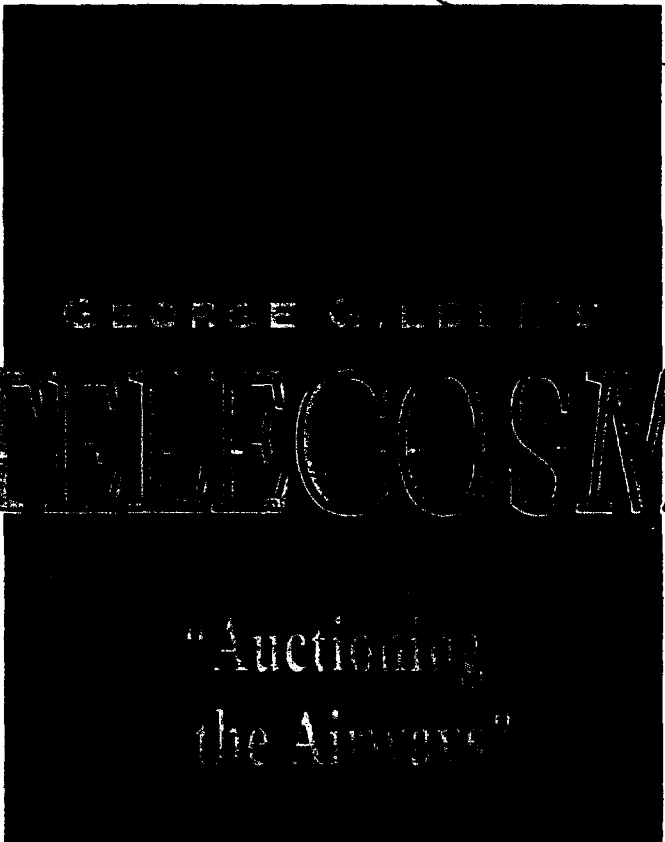
William L. Schubert

cc: Senator Diane Feinstein
Senator Barbara Boxer
Congressman Randy Cunningham

Imagine it is 1971 and you are chair of the new Federal Computer Commission. This commission has been established to regulate the natural monopoly of computer technology as summed up in the famous Grosch's Law. In 1956 IBM engineer Herbert Grosch proved that computer power rises by the square of its cost and thus necessarily gravitates to the most costly machines.

According to a famous IBM projection, the entire world could use some 55 mainframes, time-sharing from dumb terminals and keypunch machines. The owners of these machines would rule the world of information in an ascendant information age. By the Orwellian dawn of 1984, Big Bre'r IBM would establish a new digital tyranny, with a new elite of the data-rich dominating the data-poor.

As head of the computer commission, you launch a bold program to forestall this grim outcome. Under a congressional mandate to promote competition for IBM and ensure the principle of universal computer service, you ordain the creation of some 2,500 mainframe licenses to be auctioned to the highest bidders (with special licenses reserved for minorities, women and farmers). To ensure widespread competition across all of America, you establish seven licenses in each metropolitan Major Trading Area and seven in every rural Basic Trading Area as defined by Rand McNally. To guarantee universal service, you mandate the free distribution of keypunch machines to all businesses and households so that they can access the local computer centers.



In establishing this auction in 1971, you had no reason at all to notice that a tiny company in Mountain View, Calif., called Intel was about to announce three new technologies together with some hype about "a new era of integrated electronics." After all, these technologies—the microprocessor; erasable, programmable read-only memory (EPROM); and a one-kilobit dynamic random access memory (DRAM)—were far too primitive to even compare with IBM's massive machines.

The likely results of such a Federal Computer Commission policy are not merely matters of conjecture. France pretty much did it when it distributed free Minitel terminals to its citizens to provide them access to government mainframes. While the United States made personal computers nearly ubiquitous—buying perhaps 100 million since the launch of the Minitel in the late 1970s—the French chatted through central databases and ended up with one-quarter as many computers per capita as this country, and one-tenth the number of computer networks. Today, PC networks are leading the U.S. economy to world dominance while Europe founders without a single major computer company, software firm or semiconductor manufacturer.

It is now 1994, and Reed Hundt, the new chairman of the Federal Communications Commission, is indeed about to hold an auction.

Rather than selling exclusive mainframe licenses, the current FCC is going to sell exclusive ten-year licenses to about 2,500 shards of the radio spectrum. Meanwhile, a tiny company called Steinbrecher Corp. of Burlington, Mass., is introducing the new microprocessor of the radio business.

In the world of radio waves ruled by the Federal Communications Commission, the Steinbrecher MiniCell is even more revolutionary than the microprocessor was in the world of computing. While Intel put an entire computer on a single chip, Steinbrecher has put an entire cellular base station—now requiring some 1,000 square feet and costing \$1.5 million—in a box the size of a briefcase that costs

Today [illegible] networks [illegible] leading the U.S. economy [illegible] dominance. Europe [illegible] without a single major [illegible] company [illegible] or semiconductor manufacturer. Does the FCC want [illegible] telecom [illegible]

$100,000 today. Based on a unique invention by Donald Steinbrecher and on the sweeping advance of computer technology, the MiniCell represents a far bigger leap forward beyond the current state of the art than the microprocessor did. What's more, this MiniCell is in fact much superior to existing cellular base stations. Unlike the 416 hard-wired radio transceivers (transmitter-receivers) in existing base stations, the MiniCell contains a single digital broadband radio and is fully programmable. It can accommodate scores of different kinds of cellular handsets.

Most important, the MiniCell benefits from the same technology as the microprocessor. Making possible the creation of this broadband digital radio is the tidal onrush of Moore's Law. In an antithesis of Grosch's Law, Gordon Moore of Intel showed that the cost-effectiveness of microchip technology doubles every 18 months. This insight suggested the Law of the Microcosm—that computing power gravitates not to the costliest but to the cheapest machines. Costing $100,000 today, the MiniCell will predictably cost some $10,000 before the turn of the century.

In time, these digital MiniCells will have an impact similar to that of the PC. They will drive the creation of a cornucopia of new mobile services—from plain old telephony to wireless video conferencing—based on ubiquitous client/server networks in the air. Endowing Americans with universal mobile access to information superhighways, these MiniCells can spearhead another generation of computer-led growth in the U.S. economy. Eventually, the implications of Steinbrecher's machines and other major innovations in wireless will crash in on the legalistic scene of the FCC.

And that's only the beginning of the story.

Going on the block in May will be 160 megahertz (millions of cycles per second) of the radio frequency spectrum, divided into seven sections of between 10 and 30 megahertz in each of 543 areas of the country, and devoted to enhanced Personal Communications Services (PCS).

Existing cellular systems operate in a total spectrum space of 50 megahertz in two frequency bands near the 800-megahertz level. By contrast, PCS will take four times that space in a frequency band near two gigahertz (billions of cycles per second). Because higher frequencies allow use of lower-power radios with smaller antennas and longer-lasting batteries, PCS offers the possibility of a drastically improved wireless system. Unfortunately, the major obstacle to the promise of PCS is the auction.

Amid the spectrum fever aroused by the bidding, however, new radio technologies are emerging that devastate its most basic assumptions. At a time when the world is about to take to information superhighways in the sky—plied by low-powered, pollution-free computer phones—the FCC is in danger of building a legal infrastructure and protectionist program for information smokestacks and gas guzzlers.

Even the language used to describe the auction betrays its fallacies. With real estate imagery, analysts depict spectrum as "beachfront property" and the auction as a "land rush." They assume that radio frequencies are like analog telephone circuit: no two users can occupy the same spot of spectrum at the same time. Whether large 50-kilowatt broadcast stations booming Rush Limbaugh's voice across the nation or milliwatt cellular phones beaming love murmurs to a nearby base station, radio transmitters are assumed to be infectious, high-powered and blind. If one is on the highway, everyone else has to clear out. Both the prevailing wisdom and the entrenched technology dictate that every transmitter be quarantined in its own spectrum slot.

However, innovations from such companies as Steinbrecher and Qualcomm Inc. of San Diego overthrow this paradigm. Not only can numerous radios operate at noninterfering levels in the same frequency band, they can also see other users' signals and move to avoid them. In baseball jargon, the new radios can hit 'em where they ain't; in football idiom, they run for daylight. If appropriately handled, these technologies can render spectrum not scarce but abundant.

These developments make it retrograde to assign exclusive spectrum rights to anyone or to foster technologies that require exclusivity. Spectrum no longer shares any features of beachfront property. A wave would be a better analogy.

THE NEW RULES OF WAVES

In the early decades of this century, radio was king. Electronics hackers played in the waves with a variety of ham, citizens band and shortwave machines. Experimenting with crystal sets, they innocently entered the domain of solid-state devices and acquired some of the skills that fueled the electronic revolution in the United States and the radar revolution that won World War II. The first point-contact transistor, created by John Bardeen and Walter Brattain at Bell Labs in 1948, functioned like a crystal radio. The first major solid-state product was a 1954 Texas Instruments pocket radio with six germanium transistors.

Over the following decades, the radio became a mass commodity. There are now some 230 million radios in the United States alone, not even including more than 16 million cellular phones (which are in fact portable two-way radios). Radios roll off Asian assembly lines at a rate that might be meaningfully measured in hertz (cycles per second), and they come in sizes fit for pockets, belts, watches and ears. But the romance of radio has died and given way to the romance of computers.

Today it is PC technology that engages the youthful energies previously invested in radio technology. The press trumpets a coming convergence between computers and tvs and games and films. But no one talks much about radios. For many years, we have been taking radios for granted.

As the foundation of wireless communications, however, radio—no less than tv or films—will burst into a new technoscape as a result of a convergence with computers. The hackers of the '50s and '60s are joining forces with the hackers of the '80s and '90s to create a new industry. Moore's Law is about to overrun the world of radio.

You double anything every 18 months and pretty soon you find yourself with a monster. During the 1970s and 1980s, Moore's Law overturned the established order in the computer industry and spawned some 100 million personal computers that are as powerful as million-dollar mainframes were when the revolution began. In the current decade, Moore's Law is upending the telephone and television industries with interactive teleputers that will be able to send, receive, shape and store interactive full-motion video. And during the next five years, Moore's Law is going to transform exotic and costly radio equipment once consigned to the military and outer space into the basic communications access routes for the new world economy.

To understand this new world of radio, however, you must forget much of what you learned about the old world of radio. For example, these new radios differ radically from the radios of the past in the way they use spectrum, the way they interfere with one another and the way they are built.

For some 15 years, a hacker of the 1950s named Don Steinbrecher and a small group of students and associates have been making the world's most powerful and aerobatic radios. Steinbrecher radio gear can soar to spectrum altitudes as high as 94 gigahertz to provide radar "eyes" for smart bombs and planes, plunge down to the cellular band at 800 megahertz to listen in on phone calls or drop discretely to 30 megahertz—waves that bounce off the ionosphere—for remote over-the-horizon radar work identifying cocaine traffickers flying in low from Latin America. At the same time, some of these radios may soon command enough dynamic ranges of accurate broadband reception—rumored to be as high as 120 decibels (one trillion-to-one)—to detect a pin drop at a heavy-metal rock concert without missing a high-fidelity note or twang.

Like every radio transceiver, a Steinbrecher radio must have four key components: an antenna, a tuner, a modem and a mixer. The antenna part is easy; for many purposes, your metal shirt hanger will do the trick (backyard wire fences collect millions of frequencies). But without tuners, modems and mixers, nothing reaches its final destination—the human ear.

A tuner selects a desired carrier frequency, usually by exploiting the science of resonant circuits. A modem is a modulator-demodulator. In transmitting, it applies information to the carrier frequency by wiggling the waves in a pattern, called a modulation scheme, such as AM or FM. In receiving, the modem strips out (demodulates) the information from the carrier wave.

The key to Steinbrecher radios is the broadband mixer. It surmounts what was long seen as an impossible challenge: moving a large array of the relatively high carrier frequencies on the antenna down to a so-called baseband level where they can be used without losing any of the information or adding spurious information in the process. Compared to FM carrier frequencies of 100 megahertz or even PCS frequencies of two gigahertz, baseband audio frequencies run between 20 hertz and 20 kilohertz.

Mixers were the basic Steinbrecher product, and in 1978 and 1980, Steinbrecher acquired patents on a unique broadband mixer with high range and sensitivity called the Paramixer. Even to its expected military customers, the Paramixer was a hard sell because other radio components were unable to keep pace with its performance. Today, however, the Paramixer is the foundation of the Steinbrecher radio in the MiniCell.

In the old world of radio, transceivers integrated all of these components—antenna, tuner, modem and mixer—into one analog hardware system. Because the radio is analog and hard-wired, its functions must be standardized. Each radio can receive or transmit only a very limited set of frequencies

The key to Steinbrecher radios is the broadband mixer. It surmounts what was long seen as an impossible challenge: moving a large array of high carrier frequencies down to the baseband level without adding [illegible] spurious [illegible]

bearing information coded in a specific modulation scheme and exclusively occupying a specific spectrum space at a particular power range. If you are in the radio business—whether as an equipment manufacturer such as Motorola or Ericsson, a provider of services, such as McCaw or Comsat, or a broadcaster, such as NBC or Turner—you care deeply about these hard-wired specifications, frequencies and modulation schemes.

Comprising the "air standard," these issues embroil businesses, politicians, standards bodies and regulators in constant warfare. For everything from High Definition Television to digital cellular and cordless telephony, standards bodies are wrangling over frequencies and modulation schemes.

How Digital Radios Can End the Spectrum Wars

To the people at Steinbrecher Corp., all these wrangles seem utterly unnecessary. With antennas, tuners, modems and mixers, wideband digital radios perform all the same functions as ordinary radios. Only the antenna and mixer are in hardware, and these are generic; they don't care any more about air standards than your shirt ~~hanger does.~~

~~In~~ Steinbrecher radios, all of the frequency tuning, all of the modulating and demodulating, all of the channelization, all of the coding and decoding that so embroil the politicians are performed by programmable digital signal processors and can be changed at a base station in real time. Strictly speaking, the tuner and modem are not part of the base station radio at all. The broadband radio in a Steinbrecher base station can send or receive signals to or from any handset or mobile ~~unit~~ operating within its bandwidth ~~(in~~ current cellular systems ~~the full 12.5~~ megahertz of the band; in PCS, still larger bands of as much as 30 megahertz).

All the processing of codes, frequencies, channels and modulations, ~~as well as all special mobile~~ services, can move onto computers attached to the network. Steinbrecher technology thus can open ~~up the spectrum for open~~ and programmable client/server systems like those that now dominate the computer industry. Moore's Law, in fact, is changing radios into portable digital computers. The most pervasive personal computer of the next decade ~~will be~~ a digital cellular phone operating at least 40 MIPS (millions of instructions per second).

Today the performance of analog-to-digital converters defines ~~the limits~~ of Steinbrecher radios. Even if the mixers are perfect, the ~~system's performance can be no~~ better than the accuracy of the A/D processors that transform the output of the mixers into a digital bit stream for the DSPs. Steinbrecher estimates that better broadband A/D converters—which can sample wave forms more accurately at high frequencies—could increase the performance of Steinbrecher systems by an amazing factor of 10. Pushed by demands and designs from Steinbrecher, Analog Devices and other suppliers are advancing converter technology nearly at a pace with Moore's Law, and Steinbrecher's broadband digital radios are rapidly approaching the ideal.

As Don Steinbrecher puts it, broadband A/D and DSP have changed wireless "from a radio business to a computer business." At first, the computer portion of a broadband radio was very expensive. Until the early 1980s, military customers performed advanced broadband analog-to-digital conversion and digital signal processing on million-dollar custom supercomputers. In 1986, an advanced DSP system for graphics at Bell Labs entailed the use of 82 AT&T DSP32 chips and supporting devices in a custom computer that cost some $130,000. Today, these same functions are performed on an Apple Quadra 840 AV using an AT&T 3210 running at 33 megaflops (million floating-point operations per second) and 17 MIPS for under $20 in volume. This rising tide of advances in digital technology, propelled by Moore's Law, is about to sweep Steinbrecher's recondite radio company into the midst of a mass market in cellular telephony.

And the entire cellular and PCS industries will be beating a path to Steinbrecher's door. Just as millions of people today have learned the meaning of *MIPS* and *megabytes*, millions of people around the world, believe it or not, are going to come to understand the meaning of "spurious-free dynamic range."

As a very rough analogy, imagine cranking the volume of your radio as high as possible without marring the desired signal with static and distortion. The spurious-free dynamic range of your radio would measure the distance between the lowest and the highest volumes with a clear signal. In more technical terms, spurious-free dynamic range is defined as the range of signal amplitudes that can simultaneously be processed without distortion or be resolved by a receiver without the emergence of spurious signals above the noise floor.

In building *broadband* radios with high dynamic range, however, Steinbrecher faced a fundamental technical problem. As a general rule, bandwidth is inversely proportional to dynamic range. You can have one or the other, but you can't have both. The broader the band, the more difficult it is to capture all of its contents with full accuracy and sensitivity or with full spurious-free dynamic range. An ordinary radio may command a high dynamic range of volumes because it is narrowband.

But Steinbrecher radio does not begin by tuning to one frequency alone; it grasps every frequency in a particular swath of spectrum. In some extreme Paramixer applications (94-gigahertz radar, for example), the bandwidth could be 10 gigahertz—larger than the entire range of spectrum commonly used in the air, from submarine communications at 60 hertz to C band satellite at 6 gigahertz.

In most Steinbrecher applications that require high dynamic range, however, the bandwidth runs between a few megahertz and hundreds of megahertz (compared to 30 kilohertz in a cellular phone). Unless all of the frequencies captured by the broadband radio are really present in the band rather than as artifacts of the equipment—in technical jargon, unless the signals are spurious-free—the radio user cannot tell what is going on, cannot distinguish between spurs and signals.

Steinbrecher has devoted much of his career to the grail of spurious-free dynamic range. Soon after he arrived at Massachusetts Institute of Technology in September 1961 to pursue work on device physics, he moved into the school's new Radio Astronomy Lab. The radio astronomers were using millimeter waves at 75 gigahertz to probe remote galaxies and pore through evidence of a big bang at the beginning of time. Because the return reflections from outer space were infinitesimal, the radio telescopes had to command a bandwidth of at least two gigahertz, a spurious-free dynamic range of more than 100 decibels (tens of billions-, or even trillions-to-one) and noise levels of less than 10 decibels (millionths of a watt).

Warren Mell, McCaw Cellular

The telescope signals turned out not to be spurious-free. More than 90 percent of the receiver noise—the spurious signals—originated in the frequency converter or mixer, which translated the 75-gigahertz millimeter waves in cascading analog stages of diodes and transistors, fed by tunable local oscillators, down to baseband levels that could be usefully analyzed. This impelled Steinbrecher's obsession with spurious-free dynamic range in mixers.

To achieve high dynamic range in broadband mixers, Steinbrecher discovered, was chiefly a problem of the basic physics of diodes. At the University of Florida, at ECI Corp. and at MIT, Steinbrecher had pursued studies in device physics focusing on the theory of P/N junctions—the positive-negative interfaces that create the active regions in diodes and transistors. How cleanly and abruptly they switch from on to off—how fully these switches avoid transitional effects—determines how well they can translate one frequency to another without spurs.

From this experience, Steinbrecher concluded in 1968 that receivers could be built with at least a thousand times more dynamic range than was currently believed possible. He assigned his student Robert Snyder to investigate the issue mathematically, integrating the possible performance of each component into the performance of a mixer. Snyder's results stunningly confirmed Steinbrecher's hypothesis. They predicted that in principle—with unlimited time and effort—the linearity and dynamic range of a radio could be improved to any arbitrary standard. In a key invention, Steinbrecher figured out how to create a diode circuit that could produce a perfect square wave, creating a diode with essentially zero switching time.

Steinbrecher then proceeded to put his theory into practice by developing the crucial diode and field-effect transistor arrays, mixers, amplifiers and other components necessary to build a working system of unparalleled dynamic range. Most of their advances required detailed knowledge of the behavior of P/N junctions. To this day, the performance of Steinbrecher's equipment depends on adjustment to unexpected nonlinearities and noise sources that were discovered as part of Robert Snyder's work but are still not integrated into the prevailing models of diode behavior.

Beyond radio astronomy, the people who were interested in analyzing signals of unknown frequencies, rather than tuning into preset frequencies, were in the field of military intelligence. Enemies did not normally announce in advance the frequencies they planned to use or how they would modulate them. Steinbrecher Corp.'s first major contract came in the early 1980s for remote over-the-horizon radar (ROTHR) systems used to detect planes carrying drugs from Latin America. Steinbrecher also won contracts to supply MILSTAR satellite transceivers and 94-gigahertz "eyes" for

> *The Steinbrecher radio can survey any existing swath of spectrum in real time and determine almost instantly which channels are in use and which are free. That's what convinced McCaw to [illegible] but [illegible] will [illegible] to follow them.*

smart munitions and jet aircraft.

In 1986 these large potential businesses began to attract venture capitalists, including EG&G venture partners, The Venture Capital Fund of New England and Raytheon. As often happens, the venture capitalists sought professional management. They pushed Steinbrecher upstairs to chairman and summoned a Stanford EE graduate named Douglas Shute to manage the company's move from a manufacturer of hard-sell mixers into a producer of revolutionary digital radios.

Still, Steinbrecher Corp. long remained a tiny firm occupying a dingy one-story building in a Woburn, Mass., industrial park, where it rarely pulled in more than $5 million in revenues. Not until the early 1990s, when its technology converged with Moore's Law, did the company begin to escape its niche.

COLLISION WITH TEXAS INSTRUMENTS' DSP

Indeed, strictly speaking, even Moore's Law was not enough to make this Pentagon turkey fly. Crucial was Texas Instruments' mid-1980s campaign to remake the digital signal processor into a commodity device comparable to Intel's microprocessor. Creating development systems and software tools, TI transformed the DSP from an exotic and expensive printed circuit board full of integrated circuits into a single programmable microchip manufactured in volume on the same factory floor the company used to produce hundreds of millions of dynamic random access memories. The results exceeded all expectations. Outpacing Moore's Law by a factor of nearly four for some eight years so far, DSP cost-effectiveness began soaring tenfold every two years. Pricing the devices for digital radios, Douglas Shute saw that the wideband digital radio had "moved onto the map as a commercial product."

Also in 1989, a secret contractor asked the company if its radios could snoop on calls in the cellular band. After gigahertz explorations in radio astronomy and military projects, the 12.5 megahertz of the cellular bandwidth seemed a piece of cake. Although this national security application never came through, the idea galvanized the company. If it should need a commercial market, cellular telephony was a good bet.

The pull of opportunity, however, is usually less potent than the push of catastrophe—which is the key reason for socialism's failure. Insulating the economy from failure, it also removes a key spur for success. For all the bureaucratic rigmarole of military procurement, producers for the Pentagon live in a relatively comfortable socialist world of cost plus contracts.

In 1989, however, just before the fall of the Soviet Union, Steinbrecher began to get clear signals from Washington that the market for his products was about to collapse. MILSTAR remained an experimental program; the ROTHR system was halted after the creation of just four stations with 1,600 mixers; and suddenly the cellular opportunity was not merely an attractive option—it was crucial for survival.

When Shute and Steinbrecher viewed the cellular scene in the United States, however, they became increasingly disdainful. These radio companies had no more idea of what was possible in radio technology than had the MIT engineering lab when he arrived in 1961. Indeed, Steinbrecher Corp.'s first potential customer—a wireless colossus—refused even to meet with Shute: The chief technologist said he had investigated digital radios several years before and determined they were unable to achieve the requisite dynamic range. Moreover, at scores of thousands of dollars apiece, digital signal processors were far too expensive. Most cellular executives, along with their Washington regulators, seemed stuck in a 1970s time warp when analog still ruled and DSP was a supercomputer.

IMPORTING OBSOLESCENCE

As a result, the entire industry was convulsed by what Shute and Steinbrecher saw as a retrograde war over standards. Because Europe in general lagged far behind the United States in adopting analog cellular technology, the EEC had sponsored a multinational drive to leapfrog the United States by adopting a digital standard, which could then be exported to America. The standard they chose was called GSM (global services mobile), a time-division multiple-access (TDMA) scheme that exceeded analog capacity by breaking each channel into three digital time slots. Racing to catch up, the American industry adopted a similar TDMA approach that also increased the current system's capacity by a factor of three. With McCaw Cellular in the lead, American firms quickly committed themselves to deploy TDMA as soon as possible.

Then in 1991, Qualcomm unleashed a bombshell. Exploiting the increasing power of DSPs to process digital codes, the company demonstrated a spread-spectrum, code-division multiple-access (CDMA) modulation scheme that not only increased capacity some twentyfold over analog but also allowed use of the entire 12.5 megahertz of the cellular bandwidth in every cell. To prevent interference between adjoining cells, analog and TDMA systems could use a frequency in only one cell out of seven.

Much of the industry seemed paralyzed by fear of choosing the wrong system. To Shute and Steinbrecher, however, these fears seemed entirely feckless. Using wideband digital radios, companies could accommodate any array of frequencies and modulation schemes they desired—TDMA, CDMA, voice, data and eventually even video. Shute resolved to adapt Steinbrecher's advanced radio technology to these new markets. In mid-1992, Shute rushed ahead with a program to create a prototype cellular transceiver that could process all 12.5 megahertz of the cellular bandwidth and convert it to a digital bit stream.

The first major customer for the radios turned out to be ADC-Kentrox, a designer of analog cell extenders designed to overcome "dead zones" caused by large buildings in urban areas. This system was limited in reach to the few hundred meters the signals could be sent over analog wires without deterioration. By converting the signals to digital at the remote site, the Steinbrecher radio extended this distance from hundreds of meters to scores of kilometers and allowed the price of the product to remain at $100,000.

But these gains concealed the potential impact and meaning of the Steinbrecher technology. Once again, the Steinbrecher radios are being used to complement the existing system rather than overthrow it. In a similar way, McCaw plans to buy some $30

It is as if the FCC's Reed Hundt is auctioning off beachfront property with a long list of codicils and regulations and restrictive covenants while the tide pours in around him and creates new [illegible] everywhere

million worth of Steinbrecher machines to carry through its cellular digital packet data (CDPD) network. To be provided to 95 percent of McCaw's regions by the end of 1995, CDPD is a data overlay of the existing cellular system, which allows users of the current analog system to send digital data at a rate of 19.2 kilobits per second, compared to the 9.6-kilobit-per-second rate offered by most modems over twisted-pair wires.

The Steinbrecher radio can survey any existing swath of spectrum in real time and determine almost instantly which channels are in use and which are free. It is this capability that convinced McCaw to buy Steinbrecher data cells despite the commitment of McCaw's putative owner, AT&T, to sell narrowband units made by Cirrus Logics' subsidiary Pacific Communications Sciences Inc. (PCSI), which have to scan through channels one at a time. McCaw is using the Steinbrecher radios as sniffers that constantly survey the cellular band and direct data bursts to those channels that are not being used at a particular time.

Indeed, the immediate needs of the marketplace alone justify the adoption of Steinbrecher data cells. With modems and antennas increasingly available and even moving sometime next year to PCMCIA slots the size of a credit card, demand for wireless data is likely to soar.

PCSI is now shipping a quintuple-threat communicator that fits into the floppy bay of an advanced IBM ThinkPad notebook or an Apple PowerBook, enabling them to send and receive faxes, make wireless or wire-line phone calls, dispatch data files across the existing cellular network or send CDPD packets at 19.2 kilobits per second. Speech recognition capabilities from IBM and Dragon Systems will come next year to personal digital assistants, permitting them to read or receive E-mail by voice. Although the first Newtons and Zoomers have disappointed their sponsors, the market will ignite over the next two years as vendors adopt the essential form factor of a digital cellular phone with computer functions rather than providing a kluge computer with a vaporware phone.

Nonetheless, McCaw has more on its mind with Steinbrecher than merely gaining a second source for CDPD sniffers. By simultaneously purchasing some 10 percent of the company and putting chief technical officer Nicholas Kauser on the Steinbrecher board, McCaw is signaling not a tactical move but a major strategic thrust. The Steinbrecher rollout in fact represents McCaw's stealth deployment of broadband digital capability.

Today the rival CDPD equipment from PCSI, Hughes and AT&T all can be made to perform CDPD communications as an overlay to the existing cellular phone system. However, only the Steinbrecher systems can be upgraded to perform all of the functions of a base station and more, for voice, data and video. Only Steinbrecher allows the replacement of 416 radio transceivers, one for each channel, with one broadband radio and some digital signal processing chips. Only Steinbrecher can replace a $1.5 million, 1,000-square-foot cellular base station with a box the size of a briefcase costing some $100,000 but, thanks to Moore's Law, racing toward $10,000.

It remains to be seen only whether McCaw will have the guts to follow through on this initiative by completely rebuilding its network to accommodate the wideband radio being installed at its heart. Self-cannibalization is the rule of success in information technology. Intel and Microsoft, for example, lead the way in constantly attacking their own products. But this mode of life is deeply alien to the telephone business—even an entrepreneurial outfit like McCaw.

With new software and a simple upgrade to a MiniCell, the Steinbrecher DataCell will allow the McCaw system to handle all modulation schemes simultaneously—AMPS, TDMA, CDMA and future methods such as Orthogonal Frequency Division Multiple Access—obviating the need for hybrid phones. The multiprotocol and aerobatic capabilities of broadband digital radios could enable McCaw to roll out a cornucopia of PCS services—for everything from monitoring vending machines or remote power stations to tracking trucks and packages, and linking laptops and PDAs—while the rest of the industry is still paralyzed by wrangles over incumbent users, regulatory procedures, frequency access and radio standards.

Making channel sizes a variable rather than a fixed function of radios, Steinbrecher systems offer the possibility of bandwidth on demand. They could open up the entire spectrum as one gigantic broadband pipe into which we would be able to insert packets in any empty space—dark fiber in the air.

So Stop the Auction!

So what does this have to do with the impending spectrum auction? Almost everything. Strictly speaking, the FCC is leasing 10-year exclusive rights to radiate electromagnetic waves at certain frequencies to deliver PCS. This entire auction concept is tied to thousands of exclusive frequency licenses. It has no place for broadband radios that treat all frequencies alike and offer bandwidth on demand. It has no place for modulation schemes that do not need exclusive spectrum space. Continuing to use interference standards based on analog transmissions that are affected by every passing spray of radiation, FCC rules fail to grasp the far more robust nature of digital on-off codes with error correction. By the time the FCC gets around to selling its 2,500 shards of air, the air will have been radically changed by new technology.

The FCC is fostering a real estate paradigm for the spectrum. You buy or lease spectrum as you would a spread of land. Once you have your license, you can use it any way you want as long as you don't unduly disturb the neighbors. You rent a stretch of beach and build a wall.

The Steinbrecher system, by contrast, suggests a model not of a beach but of an ocean. You can no more lease electromagnetic waves than you can lease ocean waves. Enabled by new technology, this new model is suitable for an information superhighway in the sky. You can use the spectrum as much as you want as long as you don't collide with anyone else or pollute it with high-powered noise or other nuisances.

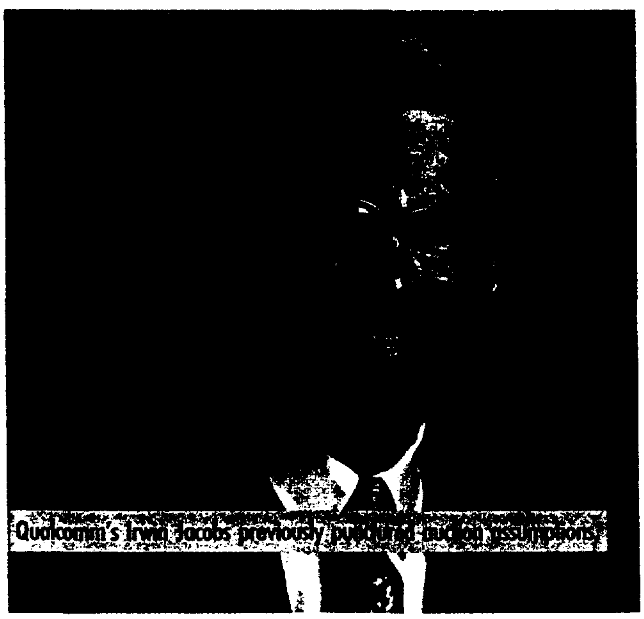
In the Steinbrecher model, you employ the spectrum as you use any public right of way. You are responsible for keeping your eyes open and avoiding others. You cannot just buy a 10-year lease and then barge blindly all over the air in a high-powered vessel, depending on the government to keep everyone else off your territory and out of your way. The spectrum is no longer dark. The Steinbrecher broadband radio supplies you with lights as you travel the information superhighway. You can see other travelers and avoid them.

Even if Steinbrecher radios did not exist, however, the assumptions of the auction are collapsing in the face of innovations by Qualcomm and other spread-spectrum companies. Like Steinbrecher radios, CDMA modulation schemes allow you to use spectrum without interfering with others. To auditors without the code, calls seem indistinguishable from noise. But radios with the code can dig up signals from under the noise floor. Up to the point of traffic congestion where the quality of the signal begins to degrade gracefully, numerous users can employ the same frequencies at the same time.

This property of CDMA has been tested in Qualcomm's CDMA Omnitracs position locator and two-way communications system. Mainly used by trucking companies, it is now being extended to cars, boats, trains and other mobile equipment. Based on geosynchronous satellites, it operates all across the country, with some 60,000 units, under a "secondary license" that forbids Qualcomm to interfere with the primary license-holders of the same frequencies. Qualcomm's transceivers on the tops of trucks use a small antenna that issues a beam six to 10 degrees in width. Because satellites are just two degrees apart, the Qualcomm beam can blanket several satellites. Other users, however, are entirely unconscious of the presence of the CDMA signal. Omnitracs has operated for some six years and has not interfered with anyone yet.

No More Blind Drivers on the Information Superhighway

With an increasing array of low-interference technologies available, the FCC should not give exclusive rights to anyone. Instead, it should impose a heavy burden of proof on any service providers with blind or high-powered systems that maintain that they cannot operate without an exclusive license, that want to build on the beach and keep everyone else out of the surf. In particular, the FCC should make all the proponents of TDMA, whether in the American or European GSM systems, explain why the government should wall off spectrum. The wireless systems of the future will offer bandwidth on demand and send their packets wherever there is room.



Qualcomm's Irwin Jacobs previously punctured auction assumptions

At the same time that new technologies make hash of the need to auction off exclusive licenses, Qualcomm and Steinbrecher also radically attack the very notion of spectrum scarcity on which the auction is based. Steinbrecher's radio makes it possible to manufacture new spectrum nearly at will. By putting one of his MiniCells on every telephone pole and down every alley and in every elevator shaft, the cellular industry can exponentially multiply the total number of calls it can handle. At some $100,000 apiece and dropping in price, these MiniCells can operate at 900 megahertz or six gigahertz just as well as at the two-gigahertz range being auctioned by the government. It is as if Reed Hundt is auctioning off beachfront property, with a long list of codicils and regulations and restrictive covenants, while the tide pours in around him and creates new surf everywhere.

Still more important in view of the coming auction, the wideband capability of the Steinbrecher radio joins CDMA in allowing the use of huge spans of spectrum that are ostensibly occupied by other users. The Steinbrecher radio can survey the gigahertz reserves of the military and intelligence services, UHF television and microwave, and direct usage to the many fallow regions. For example, the prime territory between 225 megahertz and 400 megahertz, consisting of some 3,000 25-kilohertz channels, is entirely occupied by government and air force communications. But most of the channels are largely unused. A Steinbrecher radio could sit on those frequencies and direct calls to empty slots.

An ideal system would combine Steinbrecher broadband machines with Qualcomm's modulation schemes. Steinbrecher supplies the lights and eyes to find space in already-licensed spectrum bands; CDMA allows the noninvasive entry into spans of spectrum that are in active use.

Meanwhile, the Steinbrecher system changes the very nature of spectrum "ownership" or rental. Unrestricted to a single band or range of frequencies, Steinbrecher radios can reach from the kilohertz to the high gigahertz and go to any unoccupied territory. As Steinbrecher radios become the dominant technology, the notion of spectrum assignments allotted in 2,500 specific shards becomes a technological absurdity.

Wall Street is beginning to catch on. When Steinbrecher announced in January a private placement through Alex. Brown, the company wanted to raise some $20 million. The response was overwhelming, and hundreds of frustrated investors were left wringing their hands as the new radio left the station. The sole proprietorship of the mid-1980s with revenues of $5 million or less was moving into sleek new headquarters off Route 128 in Burlington. Steinbrecher Corp. was becoming yet another of the Moore's Law monsters.

Meanwhile, the issue for Washington emerges starkly. Do we want a strategy for MiniCells or for Minitels? ASAP

The Microprocessor of telecom? Donald Steinbrecher's invention replaces 416 radio transceivers with one broadband radio and some digital signal processing chips. Soon it could replace a $1.5 million, 1,000-square-foot cellular base station with a box the size of a briefcase costing some $100,000 but, thanks to Moore's Law, racing toward $10,000.

CONCERNED STUDENTS
IMPORTANT DATES

MEETINGS EVERY TUES. 6pm
above High Price Center theater

April 9 Sat - ***Give a little Plasma for the Revolution!***
Okay, y'all we've been crippled since the Smith v. Regents con
Don't give it to 'em, sell it! Plasma drive for the unsanctioned actions of Concerned Students. Meet 9am Grove Cafe

April 13th - Community Activists Meeting 7pm
CRAFTSMAN HALL (University Ave. and Centre St.)
San Diego Coalition to Re-Prioritize Education
(City, Cuyumaca, Grossmont, Mesa, SDSU, UCSD)

April 22 Fri. - Student Unity Fair UCSD

April 29 Fri. - Community Rally and March to State Bldg. For Education. (BRING DRUMS.
San Diego Coalition to Re-Prioritize Education

May 1 Sun. - Caravan to the Capitol
Students and UC Union workers from across the state will form a caravan to converge on Sacramento for a joint press conference on May 2 Mon.

May 2 Mon. - *Party at the Capitol*
(bring your own budget)

May 19 Th. - *Party at the Regents Meeting UCLA*
(bring your own bricks)

We, the Concerned Students have formed to demand that higher education be kept affordable and accessible to all students. Inspired by and in solidarity with recent student movements across California, we oppose reduced access to public higher education.